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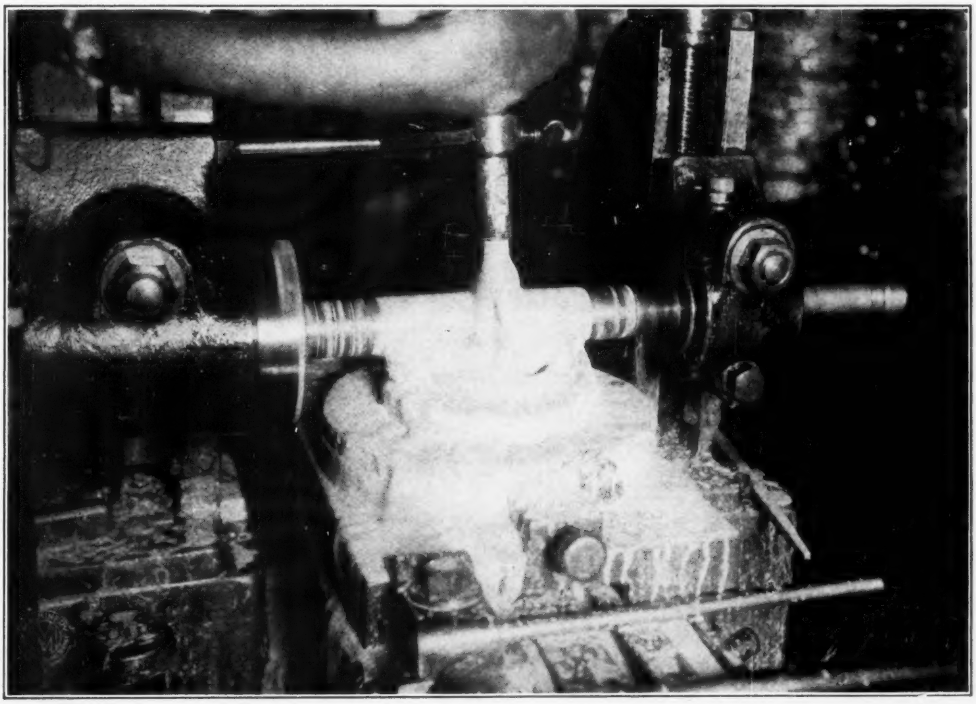


TOOL LUBRICANTS AND COOLANTS

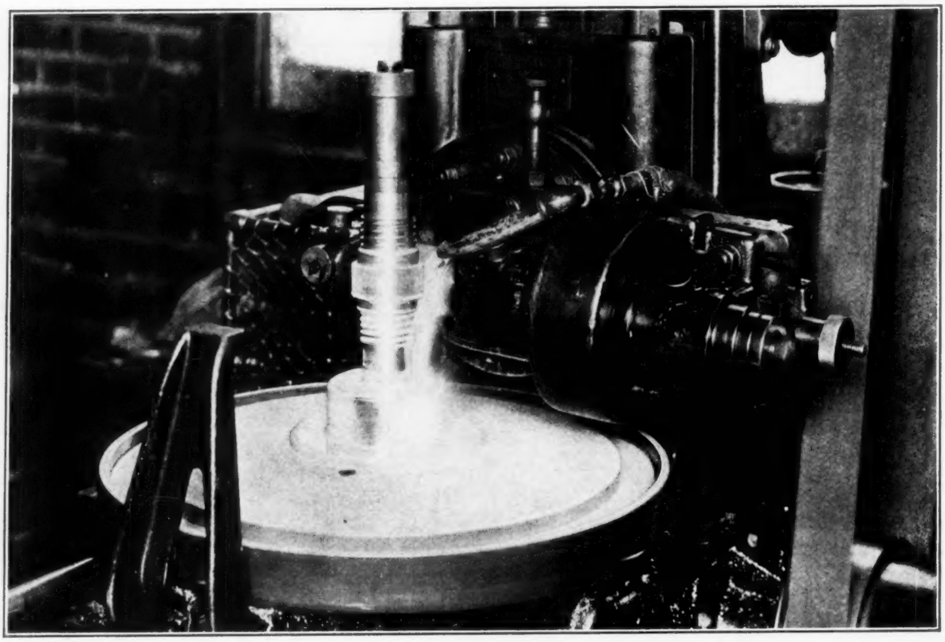
IN considering the many lubricating problems inherent in any manufacturing plant where metals are worked, the layman may not consider the matter of tool lubrication of much importance. That this is a very important factor, however, especially where quantity production is attempted, is evidenced by the large number of cutting oils and compounds found on the market. As

it was the belief that these oils and compounds have been produced by a more or less cut and dried method, an endeavor has been made to attack the problem more scientifically and get an oil which would meet the conditions far more satisfactorily than previously.

The idea of increasing production by the use of liquids applied to tools is comparatively modern. At first water only was used either in a stream or simply by being allowed to trickle upon the tool. Later a mixture of soda and water was found more efficient, as this combination tended to decrease rust formation and corrosion. Water thus used served to keep the tool cool and hence to increase production but it furnished very little, if any, real lubrication of the cutting edge. This use of water is not to be confused with its application in smoothing or polishing operations, though in the latter case the same end was unconsciously reached.

In 1884 the advantages from the use of a cooling medium became so apparent to one of the large steel companies that they equipped a shop with a circulating system for the purpose of delivering a cooling solution to all machines. This same policy was followed very shortly by other manufacturers who experimented with different solutions. The advent of high speed tools produced conditions which absolutely required the use of a lubricating as well as a cooling medium, if production was to keep pace with the possibilities of the tool, and costs were to be kept as low as practical.

That the use of a cutting lubricant is an economical proposition was plainly proven by an experiment carried on several years ago by the Bullard Machine Tool Company, Bridgeport, Conn. Cutting compound was supplied to two tools used in machining a large steel casting and the machine operated satisfactorily. When the flow of lubricant was suddenly stopped the load on the machine increased to such an extent that the driving belt slipped from the pulley before the tools had traveled half-way around the casting. This experiment was repeated several times with practically the same result. In order to determine the increase in power necessary to drive the tool when dry, a watt meter was placed in the driving motor circuit and its readings noted. It was found that one and one-half times as much energy was required



CUTTING STEEL GEARS FOR ELECTRIC HOIST AT PLANT OF VICTOR R. BROWNING, COLLEGE POINT, N. Y.

for dry running as when the tool was properly lubricated. Experiments of a similar nature made by other concerns corroborated this result and showed that a saving of about one-third of the power could be made by lubricating and cooling the tool.

It is evident, therefore, that a good cutting lubricant is a positive necessity in almost every machine shop and an economic factor to be carefully considered wherever quantity production is attempted and automatic machines are used.

In determining the type of lubricant to use, naturally the one to be preferred is the one that will give the best service at the lowest cost. Every factor pertaining to the tool operation must be considered and even the effect on the personnel must not be overlooked.

There are a very large number of lubricants and coolants on the market, a great many of which simply exist by virtue of their cheapness and have very little value in reducing operating costs.

These lubricants or coolants divide themselves into four general classes:

(a) Chemical solutions.
(b) Oils and oil compounds.
(c) Cutting compounds or pastes.
(d) Soluble oils.

In class "a" are placed those chemicals or chemical cutting solutions on the market which contain very little, if any, oil. The most important of this class is the combination of soda and water. This material was one of the first used and has little value as a lubricant but is an efficient cooling agent on account of the high specific heat of water. Soda and water is better than clear water, especially with iron metals on account of the action of the soda as a rust deterrent. Sometimes a little mineral oil is mixed in, but the combination is not satisfactory as the solution will not stay homogeneous.

Class "b" includes various fixed oils, mineral oils and combinations of these which are used as furnished without mixture with water or soda. The oils in this class are, strictly speaking, lubricants and not cooling agents in comparison to those in classes "a" and "d." Oil has a lower specific heat than water and hence is less efficient than the latter in cooling. Increasing the quantity does not completely overcome the difficulty, as in tool operations the heat is generally localized and only a small quantity of liquid can come in contact with the heated area and act effectively. Perhaps the best known and most efficient lubricant in this class is high grade lard oil. When machining operations were generally at slow speed, lubrication and not cooling, was the important factor, the quantity of oil used was not large and the proportional cost of lubrication was comparatively low. With the introduction of high grade tools, however, and the increase in cutting speed of these tools, the quantity of oil necessary for satisfactory operation became so great that with the increasing cost of lard oil it became an important factor in the cost of shop operation. This led to the compounding of lard oil with various cheaper fixed and mineral oils and produced an almost endless number of compounds which, as a rule, furnished sufficient lubrication for quantity production where exact finish was not demanded and reduction of cost was essential.

In many cases straight mineral oils of the proper viscosity are found to be more efficient lubricants than lard oil and do not possess any of the deleterious characteristics of the fixed oils. Any fixed oil when subjected to the high heat at the cutting edge of a tool will undergo some change in structure which often results in the oil becoming rancid, developing organic acids and giving off offensive odors. This soon results in the oil gumming and clogging the pipes, and otherwise becoming unfit for use. While mineral oils cannot be said to be totally unchanged with use, the change is so slight in comparison with most fixed oils used for cutting, as to become negligible. All oils, however, no matter how compounded, have low heat capacity and for rapid work do not carry off the heat as rapidly as could be desired.

Class "c" includes those combinations of oils and soaps which have been made in order to produce a paste suitable for special classes of work. These pastes have been made necessary where the work is large and where portable tools are used, as in reaming boiler

plates or expanding tubes. In most such cases the use of an oil or liquid is impractical on account of cost and inconvenience. For ordinary work these pastes are considered inefficient as they have little cooling effect and are comparatively poor lubricants.

There should be included in the above class those pastes which are made for the purpose of mixing with water to form a soapy emulsion, and which are used in a manner similar to oils. While these, on account of their cheapness and good cooling qualities, may have a place in very rough work, they have poor lubricating value and are difficult to prepare. As a general rule they must be mixed with hot water and must be continually stirred to prevent settling out.

Class "d" represents those recently perfected oil combinations which have been so treated and compounded that they are miscible with either hot or cold water to form a permanent liquid which remains emulsified under continued use. It is the aim of the manufacturer of soluble oils to produce a material which will combine all the good features of the other classes and at the same time give a product which is a better cooling medium and, what seems most important, one which is low in price. Oils as a general rule will not mix with water and stay mixed, but some of them can be so treated and combined as to overcome this difficulty and still retain their lubricating qualities. There are a great number of these soluble oils on the market, the final value of which depends upon how scientifically they are made and how well they achieve their object of giving a maximum of lubrication with a maximum cooling effect, and at the same time of being easy to handle and reasonable as to price. They are superior to straight oils in having a high cooling effect while still retaining sufficient lubricating value. They are superior to pastes in having a greater lubricating value upon mixture with water and are much easier to handle in practice. The best soluble oils can be mixed with cold water as well as hot, it being necessary only to add to the storage vat the proportions of water and oil found best for each kind of work.

In order to properly ascertain the advantages and disadvantages of the various classes of lubricants enumerated above, it seems best to discuss in detail the various operations which these lubricants or coolants are called upon to render more efficient by their use.

A cutting liquid or paste is applied to a tool for the following general reasons:

1. To cool the metal being worked.
2. To cool the lip of the cutting tool.
3. To lubricate the surface of the cutting tool.
4. To wash away the chips.
5. To protect against corrosion and rust.

The distortion of the chip and its friction, and that of the main body of metal against the tool, generate heat which raises the temperature of the tool and work. As far as the work is concerned, this generation of heat may not be serious except as it may not dissipate due to insufficient radiation and cause the work to expand and be cut undersize. With most classes of work any of the lubricants or coolants will correct this difficulty, the material having the greatest heat capacity being most efficient. Water is the best coolant and the product carrying a large percentage of water is more efficient than oils.

This same condition holds true as far as actual cooling of the tool is concerned. Water generously applied will keep the tool cool if no account is taken of the condition of the cut and the power consumed. But power is a very important factor in most operations and it is necessary not only to carry away the heat but also to prevent, if possible, its being formed.

The formation of a chip by a tool is essentially a breaking, shearing or bending operation, or a combination of these according to the character of the operation and the metal worked. With cast iron the action is almost purely one of breaking off the chips and there is very little side pressure on the tool. In general a lubricant is not necessary but in rapid operations a cooling agent may be required. With the softer metals, as brass and bronze, there may be more or less rubbing action on the tool according to the

operation, and lubrication between the tool and metal becomes important. In this case it is essential to have a lubricant as well as a coolant. This is particularly true if a heavy cut is taken. When steels are machined the bending and shearing action is very pronounced and there may be enormous pressure between the metal and the tool. To reduce the friction as much as practical, a liquid should be used which has very high lubricating value. It is doubtful if oil ever gets up to the very tip of the tool, but that lubricant is most efficient which gets up to the point as far as possible, at the same time having sufficient body to prevent to the greatest degree, metallic contact between the surfaces.

The carrying away of the chips is essentially a mechanical proposition depending on the proper design of the oil feed.

In working steel, and in a less degree other metals, it is highly important that a liquid shall be used which prevents rusting. It has been found that a very high percentage of water can be added to a soluble oil and still the emulsified product will possess sufficient adhesiveness to coat the metal with oil and prevent the water and air from causing rust.

From the preceding discussion it might appear that the superintendent or engineer of a plant which is engaged in quantity production, would of necessity be required to maintain a supply of a large number of lubricants in order to get the maximum efficiency with each machine. The advent of soluble oils, however, has simplified his problem to a large extent, so much so, indeed, that in a very large majority of the cases where the cost of oil is an important factor compared to other costs, he has a liquid which is not only reasonable in price but efficient in action. It cannot be denied that in some cases where extreme smoothness and exactness are required, as in tool and die making, lard oils are at present more efficient than other oils, but these cases are few and the relative cost of the oil small compared to the value of the work. In the great majority of cases sufficient accuracy can be obtained at high speed by the use of soluble oils, if properly made and a correct mixture with water used.

It then becomes the problem of the lubricating engineer to produce a soluble oil which will give the best results for the greatest range of cases. In compounding this oil he is bound by certain requirements. The oil when mixed with water in the proportions required for use, should lubricate the tool with the same practical results as a pure oil; it should cool the tool and the work efficiently; it should prevent rust; it should be miscible with water in all proportions and remain in an emulsified state for a long period, and above all, it should not deteriorate or have any bad effects on the personnel.

In the problem of efficiency in production the effect on personnel must not be overlooked. Lard oils after a short time become rancid and gummy and give off disagreeable odors. It is claimed that they and many other fixed oils often develop bacteria which may infect the hands of the operators. Many soluble oils contain ammonia, carbolic acid or creosote. When these oils are heated by contact with the tool they become very obnoxious to the men handling them and certainly are conducive to a decrease in the efficiency of the operators.

From the foregoing it is evident that the lubricating engineer has no small problem, and one which can be satisfactorily solved only after research and a long series of experiments with oil scientifically treated in different ways, and tried out in actual service tests on a great number of machines working under various conditions. The responsibility of an engineer of a large company in developing a product is great, but no less than that of a superintendent or engineer of a manufacturing plant who has to choose the proper oil to use on his machines. The cost of oil, though important, is not to be compared with the loss that may be incurred by a wrong decision. The plant engineer naturally desires to get the product which will give him the maximum results for the least amount of money expended, but he has no time or facilities for making exhaustive tests and must depend on the results of tests shown to him, at the same

time taking into consideration the reliability of the people who have made these tests, and those who make the product.

In the development of soluble oils a very large number of experiments have been made and much valuable data obtained. It is proposed in subsequent articles to give the manufacturer the results of these tests, so that he may benefit by this research in the selection of the oil best suited to his needs.

Motor Oil Specifications.

The specifications for Motor Oils (3502-F) recently issued by the War Department to govern the purchasing of lubricants by the United States Army, for use in internal combustion engines, other than airplane and motorcycle types, indicate such a marked improvement in the preparation of specifications for oils that we feel that our readers should be informed as to their general import and character.

Several years ago, Lubrication, March, 1912, we called our readers' attention to the fact that specifications for oils were largely prepared without due consideration being given to the purpose for which the oils were to be used. Instead of emphasizing and requiring those characteristics which pertained directly to the object for which the oil was to be purchased, it was the tendency to incorporate in specifications a lot of irrelevant requisites which often prohibited the oil producer from giving the best service to the purchaser. This was often due to the fact that specifications were prepared by people who understood the situation only in a superficial manner and did not take the reliable and experienced oil man into their confidence. They found an oil that operated fairly satisfactorily, obtained all possible data about that particular oil and then gathered them together in a specification. While this procedure assured the purchaser of one source of supply, and when crudes were largely obtained in one district it produced some competition, nevertheless, it was irrational and unbusinesslike. With the discovery of new fields from which satisfactory crudes could be obtained, and proof that oils might have very different physical and chemical characteristics and still be equally efficient in attaining the result for which they were intended, the above type of specification became purposeless and inefficient.

The oil business is a progressive one and due to the discovery of new sources of supply and new experimental developments, oil products are altered and improved at a rapid rate. The best yesterday may be considered mediocre today. Specifications, therefore, to keep pace with development and procure the most suitable product, must be changed continually. We are pleased to see that the War Department has appreciated this fact and after obtaining the opinion and advice of the most reliable oil producers and refiners, has written a specification on motor oils which specifies characteristics and tests that have to do with the lubrication of motors and nothing else.

In this specification the War Department confines itself to three grades of motor oil, light, medium and heavy, and each of these grades is given as broad limits as is considered compatible with the best commercial practice. Only highly refined straight mineral oils without admixture of fatty oils, resins, soap and other compounds not derived from crude petroleum, are to be considered and they must be so well refined or treated that a clean copper plate shall not be discolored when submerged in the oil for 24 hours at a temperature of 130 degrees F.

The following essential properties and tests are specified.

	Light	Medium	Heavy
Viscosity at 100 degrees F. Saybolt Universal	175-210 sec.	275-310 sec.	475-510 sec.
Viscosity at 210 degrees F. Saybolt Universal	40-47 sec.	45-54 sec.	55-68 sec.
Flash, Minimum, Cleveland Open Cup	325 degrees F.	335 degrees F.	350 degrees F.
Fire, Minimum, Cleveland Open Cup	370 degrees F.	385 degrees F.	400 degrees F.
Carbon Residue, American Society for Testing Materials, Maximum	0.3 per cent.	0.5 per cent.	0.7 per cent.
(Hard carbon residue in service will be cause for rejection)			
Pour Test, American Society for Testing Materials, Maximum	35 degrees F.	40 degrees F.	50 degrees F.

Acidity: Not more than 0.05 milligram of potassium hydroxide should be required to neutralize 1 gram of oil.

In addition to these, a determination of emulsifying properties is also specified. Where oils are used only with the usual types of internal combustion engines, this latter test is unimportant. All tests, unless otherwise specified, must be made in accordance with methods adopted by the American Society for Testing Materials, the details of which if not known, can be obtained in War Department specification 2-20 which may be had upon application.

The test which is emphasized in these specifications is that of viscosity, the other tests being merely determinations of maximum or minimum values which are necessary to insure oils which will be safe to use without undue loss from decomposition and without developing detrimental compounds which would cause trouble in use.

Briefly stated, the purpose of lubrication is to substitute for the destructive friction of metal on metal the less destructive friction of metal on oil, and to supply a cooling agent for carrying off or absorbing the heat from the metal. Oils are fluids that possess an adhesive property with the faculty of motion of their own particles that will prevent friction. The lubricating value of an oil is almost universally deduced from its viscosity, the best oil to use being the least viscous which will prevent actual metal contact

The viscosity of an oil is the measure of its internal friction, its resistance to flow or the joint effect of its properties of cohesion and adhesion. Although the figures for viscosity given by commercial viscosimeters are purely arbitrary, they do, however, furnish a satisfactory comparative indication of the viscosities of different oils. The dimensions of the Saybolt Universal Viscosimeter have been standardized by the United States Bureau of Standards. These dimensions have been adopted by the American Society for Testing Materials and are published in the Society's tentative test for the viscosity of lubricants. From tables published by the Bureau of Standards (*) it is also possible to convert the Saybolt readings for viscosity into absolute viscosity.

It is to be noted that gravity and color tests are not included in the above specifications, as neither of these properties has any influence on the choice of a lubricant, particularly for motor cylinder lubrication. Gravity and color have nothing to do with the usefulness of an oil, and should no longer be depended upon as a means of identification or determination of value. The other tests which are specified indicate the degree of refining.

The minimum flash points specified are sufficiently high for the intended use of the oils. The fire points are probably superfluous since in petroleum products of this sort the fire is entirely dependent on the flash. Many erroneous ideas concerning the flash point of lubricating oil have had to be combated by oil manufacturers, the most preposterous of them being that the flash point was the temperature at which an oil would ignite spontaneously. The only requirement for a lubricating oil from the standpoint of flash is that it be sufficiently above the average working temperature to give a proper margin of safety. The carbon residue test, especially the qualifying clause, "Hard carbon residue in service will be cause for rejection," should be ample provision to guard against the admission of a poorly refined oil or one unsuited for internal combustion engines.

The maximum values for the pour test are not too high for oils for general motor use. Local conditions or climate may, of course, make it necessary at times to use oils of lower pour test than the minimum given in these specifications.

The acidity and emulsion tests give information of value regarding the refining and purity of the oils.

(*) Bulletin No. 100, published by the U. S. Bureau of Standards.

These specifications indicate a distinct advance in the right direction and should enable the War Department laboratory to detect inferior oils, and oils unsuitable for the lubrication of gasoline engines. Practically all the tests specified have been standardized by the American Society for Testing Materials, and, therefore, all uncertainty regarding the methods of making them, and the instruments to be used, are eliminated.

The adoption of such practical specifications for motor oils opens up increased development possibilities for the lubricating oil engineer. The growing demand for higher grade motor oils has gradually limited the output and increased the price, for while new requirements have been added, old ones have not been discarded. The acknowledgment of such an important branch of the government as the War Department that specifications had been drawn too rigidly and contained many non-essentials, will give the public confidence in the engineer when he recommends an oil which conforms perfectly to specifications from which the non-essential features have been removed. It will be found that these features are not essential to even the most exacting motor practice and that their rejection, in addition to increasing the available supply of satisfactory motor oil, will prevent unreasonable increases in price. The War Department has established a precedent which should be emulated by others in the production of specifications, as this will create closer cooperation between purchaser and producer.

TEXACO LUBRICATION ENGINEERS
and
TEXACO LUBRICANTS

For years, Texaco Lubrication Engineers have been out in the field observing, testing, checking lubricants at work.

They have met every kind of mechanical condition possible.

They are daily making field and block tests on all kinds of machinery to determine the proper lubricants.

Their daily technical reports are sent to the Home Office, digested and compiled, and the results derived are sent out to the rest of the field.

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